Holomorphic Embedded Load Flow for Autonomous Spacecraft Power Systems, Phase II

Completed Technology Project (2015 - 2017)

Project Introduction

The proposed innovation advances the ability to apply the Holomorphic Embedding Load Flow Technology (HELM™) method to provide deterministic load flow modeling for spacecraft power systems. Future deep-space vehicles need intelligent, fault-tolerant and autonomous control of power management and distribution. Due to communications latency, control algorithms for future autonomous space power systems need to be very robust, highly reliable and fault tolerant. Modeling of load flows is vital both to design spacecraft power systems and to operate them autonomously. A key element is state estimation —given the available sensors and their readings, what is the real state of the system? What action is required to maintain operation? State estimation is especially important when the system is in an off-nominal condition. Human operators draw upon experience to integrate off-nominal sensor readings and develop a gestalt of system state, but autonomous operation requires computation. Current modeling techniques (i.e., Newton-Raphson (NR) optimization) are not equal to this task due to their iterative nature and initial point dependency. Many off-nominal cases cannot be solved at all using NR. Worse, even more off-nominal cases appear to be solvable using NR, but the solutions are actually invalid. An NR-based autonomous control system faced with off-nominal conditions will reach an incorrect conclusion more often than not, with potentially catastrophic consequences for the spacecraft. By contrast, HELM™ provides deterministic solutions for off-nominal states, without dependence on initial solution seeds, thereby providing the level of fidelity and surety needed to develop an autonomous system. In Phase I, Gridquant Technologies LLC successfully adapted HELM™ to solve the non-linearity problems of a small DC micro-grid, which will enable NASA to develop and implement the advanced architectures needed for future long-term deep-space exploration.

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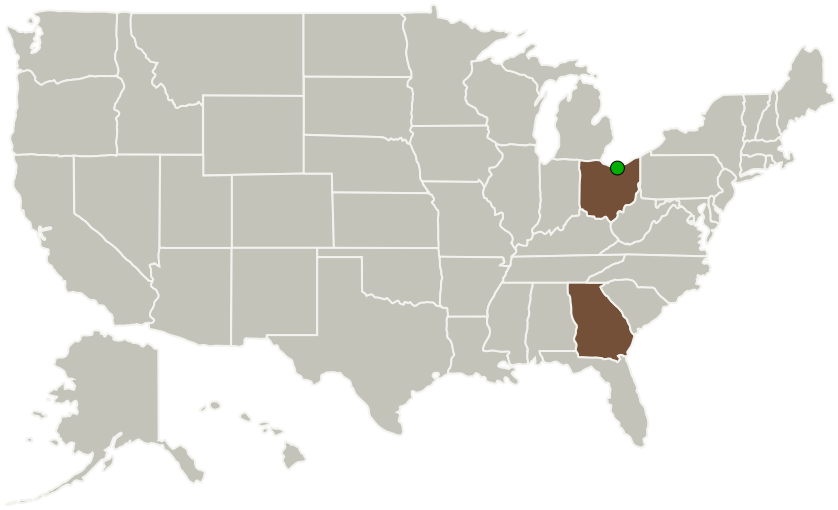
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Gridquant Technologies, LCC	Lead Organization	Industry	Duluth, Georgia
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
Georgia	Ohio

Project Transitions

May 2015: Project Start

May 2017: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/137790)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Gridquant Technologies, LCC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

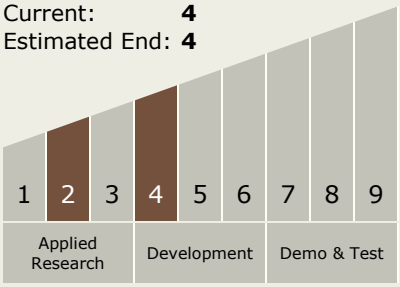
Carlos Torrez

Principal Investigator:

Bradley Glenn

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **4**



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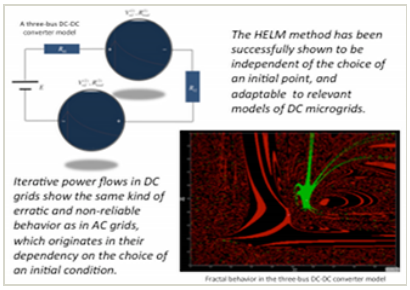
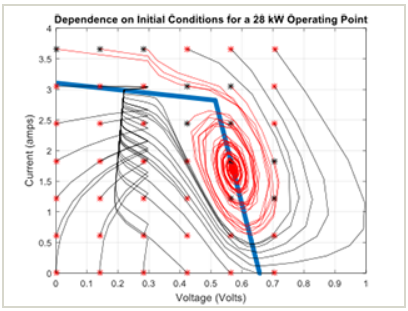
Images



Briefing Chart
Holomorphic Embedded Load Flow for Autonomous Spacecraft Power Systems Briefing Chart *(https://techport.nasa.gov/image/134270)*



Final Summary Chart Image
Holomorphic Embedded Load Flow for Autonomous Spacecraft Power Systems, Phase II Project Image *(https://techport.nasa.gov/image/133353)*

Technology Areas

Primary:

- TX03 Aerospace Power and Energy Storage
  - TX03.3 Power Management and Distribution
    - TX03.3.1 Management and Control

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System